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OPERATOR'S MANUAL

MODEL 460
DIGITAL
VOLT-OHM-MILLIAMMETER

SIMPSON ELECTRIC COMPANY

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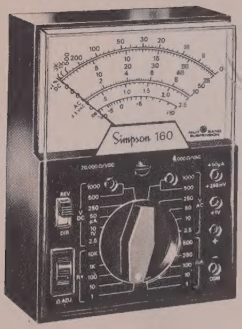

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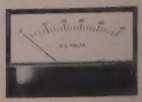

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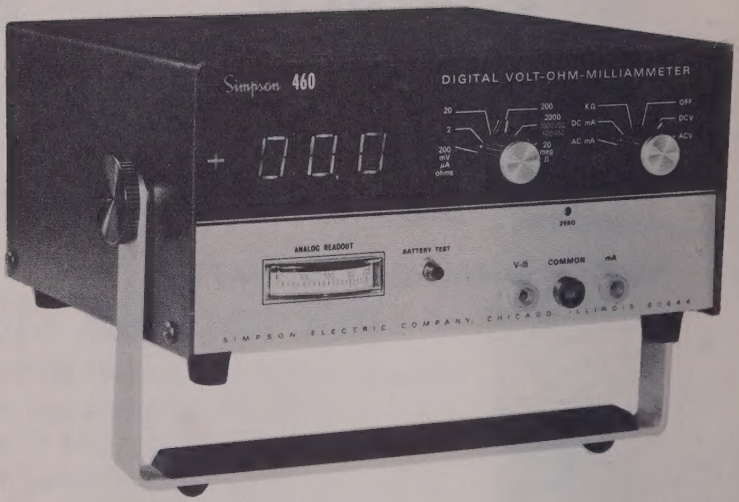

Figure 1-1
Simpson 460 Digital Volt-Ohm-Milliammeter

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SECTION I

INTRODUCTION

WARNING

The Simpson 460 is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to do so may result in a SERIOUS or FATAL accident.

1.1 GENERAL

1.1.1 The Simpson 460 Digital Volt-Ohm-Milliammeter is a precision 3½ digit instrument for both portable and laboratory applications. Features include 0.1% accuracy; solid state, integrated circuit electronics; self contained ac and battery operation; and both digital and analog readouts. Additional features are automatic polarity, excellent temperature characteristics, and exceptional overranging capability.

1.1.2 The Simpson 460 is designed to measure dc voltage, ac voltage, dc resistance, dc current, and ac current as specified in Table 1-1. The dual slope integration technique is used for the analog-to-digital conversion because of its inherent excellent stability, accuracy, and noise immunity. The careful use of integrated circuits achieves high reliability, low power dissipation, and a compact design.

1.1.3 For general type applications the Simpson 460 can be operated from a 117 or 234 volts ac (50 to 400 Hz) power

source (Check rear panel designation). For applications requiring complete isolation from the power line, battery operation is provided using rechargeable, nickel cadmium batteries. Recharging is automatic when the Instrument is operating from the power line, or when it is turned off with the line cord connected. If necessary, commercially available, D size (flashlight type) cells can be used. This reduces the operating time to approximately 2 hours. Refer to Section 6.5 for precautions and instructions.

1.1.4 The digital readout is a 3½ digit, seven segment, fluorescent display. The digits are .57 inch high and in a single plane for distant and wide angle viewing with low power dissipation. Ambient lighting effects are minimized by a filter which reduces reflections and background illumination.

1.1.5 The analog readout uses an edgewise meter and provides quick and convenient indications for nulling, peaking, scanning, and other varying or approximate measurement applications.

1.2 ACCESSORIES AND SUPPLIES

All supplies and accessories required for the operation of the instrument are furnished with the instrument and listed in Table 7-1.

1.3 TECHNICAL DATA

Table 1-1 lists the technical specifications for the Simpson 460 Digital Volt-Ohm-Milliammeter.

Table 1-1 TECHNICAL DATA

1. DC Voltage:

	Maximum Indication	Input Impedance	Overload Protection
200 mV	199.9 mV	$\geq$100 MΩ	350 V
2 V	1.999 V	$\geq$1000 MΩ	350 V
20 V	19.99 V	10 MΩ	1000 V
200 V	199.9 V	10 MΩ	1000 V
*1000 V	*	10 MΩ	1000 V

*Instrument rating on 1000 V range is 1000 V maximum.

Accuracy:	From + 10°C to + 40°C: ± 0.1% of reading ± 1 digit
Input Bias Current:	7 ηA maximum at reference conditions
Resolution:	100 microvolts
Temperature Coefficient:	From O°C to +55°C: ±(0.005% of reading +0.1 digit) /°C
Full Range Step Response: (to rated accuracy)	2 seconds
Normal Mode Rejection:	35 db minimum at 60 Hz.
Common Mode Rejection:	80 db minimum with 1kΩ unbalance at 60 Hz. In battery operation and not charging, the CMR ratio is improved.

2. Resistance:

Range	Maximum Indication	Test Current	Overload Protection
200 Ω	199.9 Ω	1 MA	250 V rms
2 kΩ	1.999 kΩ	100 uA	250 V rms
20 kΩ	19.99 kΩ	10 uA	250 V rms
200 kΩ	199.9 kΩ	10 uA	250 V rms
2000 kΩ	1999 kΩ	1 uA	250 V rms
20 MΩ	19.99 MΩ	100 nA	250 V rms

Accuracy: From +10°C to +40°C: ±0.5% of reading ± 1 digit except on the 20 MΩ range, which is ±1% of reading ± 1 digit

Resolution: 0.1 ohm

Temperature Coefficient: From 0°C to +55°C: ± (0.05% of reading +0.1 digit)/°C

Full Range Step Response (to rated accuracy): 2 seconds on ohms and kΩ ranges; 6 seconds at 10 MΩ; 10 seconds at 20 MΩ.

3. **AC Voltage (average responding, rms calibrated):**

Range	Maximum Indication	Input Impedance	Overload Protection
200 mV	199.9 mV	1MΩ at 150 pf.	250 V
2 V	1.999 V	1MΩ at 150 pf.	250 V
20 V	19.99 V	1MΩ at 150 pf.	600 V
200 V	199.9 V	1MΩ at 150 pf.	600 V
*600 VAC	*	1MΩ at 150 pf.	600 V

*Instrument rating on 600VAC range is 600 V rms (for pure sine waves) or the equivalent peak to peak maximum.

Accuracy: From +10°C to +40°C:
± 0.5% of reading ± 1 digit, 40 Hz to 10 kHz
± 1.0% of reading ± 1 digit, 10 kHz to 20 kHz

Resolution: 100 microvolts

Full Range Step Response (to rated accuracy): 5 seconds

Temperature Coefficient: From 0°C to +55°C:
± (0.05% of reading +0.1 digit)/°C, 40 Hz to 10 kHz
± (0.1% of reading +0.2 digits)/°C, 10 kHz to 20 kHz

4. DC Current:

Range	Maximum Indication	*Voltage Drop	Overload Protection
200 uA	199.9 uA	100 mV	3 amperes
2 mA	1.999 mA	100 mV	3 amperes
20 mA	19.99 mA	100 mV	3 amperes
200 mA	199.9 mA	100 mV	3 amperes
2000 mA	1999 mA	100 mV	3 amperes

*Based on a numerical indication of 1000

Accuracy: From +10°C to +40°C: ±0.2% of reading ±1 digit, except on 2000 mA range, which is ±0.5% of reading ± 1 digit

Resolution: 100 nanoamperes

5. AC Current (40 Hz to 10 kHz):

Range	Maximum Indication	*Voltage Drop	Overload Protection
200 uA	199.9 uA	100 mV	3 amperes
2 mA	1.999 mA	100 mV	3 amperes
20 mA	19.99 mA	100 mV	3 amperes
200 mA	199.9 mA	100 mV	3 amperes
2000 mA	1999 mA	100 mV	3 amperes

*Based on a numerical indication of 1000.

Accuracy: From +10°C to +40°C: ±0.7% of reading ±1 digit, except on 2000 mA range, which is ±1.0% of reading ± 1 digit

Resolution: 100 nanoamperes

6. Input Isolation:

1000 V (dc plus peak ac) maximum from COMMON terminal to instrument case.

7. Overrange Capability:

Linear to 150% overrange based on an indication of 1000 except on 600V ac and 1000V dc ranges.

8. Readout:

Digital Display: 3½ digits, 7 segment, fluorescent type, non-blinking with storage. Conversion Rate: 5 readings per second. Overrange indication: Automatic beyond 1999; lower half of the 1 digit is blanked out, and the upper half "flashes" intermittently from off to on.

Analog Display: 1½" edgewise meter with 0 to 200 scale markings.

9. Power Requirement:

AC: 117 Vac or 234 Vac±10% (Check rear panel designation), 50 to 400 Hz.

10 VA (nominal): without battery installed.

15 VA (nominal): with battery installed and charging, and Instrument on.

7 VA (nominal): with battery installed and charging, and Instrument OFF.

Battery Operation: Four, nickel cadmium, "D" size cells, Eveready type CH4 or Burgess CD10 or equivalent; rechargeable, 1.25 V at 4 ampere-hours.

Operation time (continuous) with fully charged battery - 7 hours (nominal). Recharge time - 16 hours (nominal). Unit can be operated while batteries are being charged.

10. **Operating Temperature Range:**
    0°C to +55°C

11. **Reference Conditions:**

    +25°C ±1°C, 50% relative humidity

12. **Weight (with batteries):**
    6½ pounds (nominal)

13. **Dimensions:**
    4" high, 8½" wide, 8" deep
    (not including panel controls)

SECTION II

INSTALLATION

2.1 UNPACKING AND INSPECTION

2.1.1 Examine the shipping carton for any sign of damage prior to unpacking. If there is none, inspect the Instrument and packing material for obvious damage from shock, water leakage, or other faults. The Instrument should be physically free of marks or scratches, and the electrical performance should be checked as soon as possible. If there is any indication of damage, file a complaint with the carrier immediately. Also check that all accessories are included (Refer to Table 7–1).

2.1.2 The shipping carton and packing materials should be saved for future storing or shipping of the instrument.

2.2 POWER SOURCE REQUIREMENTS

CAUTION

Do not insert the Simpson 460 line cord plug into the line power source until instructed to do so. Check that the designation on the rear panel agrees with the power source to be used.

2.2.1 The Simpson 460 is designed to be operated from either the ac line or self contained nickel cadmium cells (not furnished with the instrument). Refer to Table 1-1.

2.2.2 AC Line Operation: The Simpson 460 is wired at the factory for 117 volts rms operation. For 234 volt operation, consult your nearest Simpson representative.

WARNING

For ac line operation, be sure that the grounding pin of the power plug is securely connected to an earth (power line) ground. Preferably, use a 3-wire grounded outlet which conforms to the latest electrical code.

2.2.3 Battery Operation:

WARNING

Whenever the Simpson 460 is used with the Line cord disconnected, the rear panel GROUND terminal must be connected to to a secure earth ground.

a. The Simpson 460 is supplied without cells. The cells required (Refer to Table 1-1, item 9) can be purchased from a local electronic parts distributor.

b. Battery operation is automatic whenever cells are installed, the line cord is disconnected, and the function switch is not in the OFF position.

c. For battery installation and battery test refer to 6.5.

2.3 INSTALLATION

The Instrument can be set horizontally on the bottom four rubber feet or vertically on the rear four feet and operated in either position. It can also be set at an inclined angle by positioning the carrying handle under the unit. To release the handle for carrying or repositioning, turn the knurled thumb screws which hold the handle counterclockwise. To "lock" the handle in a fixed position, turn the thumb screws clockwise until finger tight. Do not over-tighten.

SECTION III

CONTROLS, CONNECTORS, AND INDICATORS

All operating and adjustment controls, connectors and indicators are described in Table 3-1. Become thoroughly familiar with each, prior to operating the instrument for the first time.

Table 3-1. Controls, Connectors and Indicators

Figure 3-1, Front Panel

1. Function switch

This is a six position rotary switch:

AC mA – Connects the COMMON and mA jacks to the ac current measuring circuits

DC mA – Connects the COMMON and mA jacks to the dc current measuring circuits.

KΩ – Connects the COMMON and V–Ω jacks to the resistance measuring circuits

OFF – Disconnects ac power from all circuits except the battery charging circuit.

DCV – Connects COMMON and V–Ω jacks to the dc voltage measuring circuits

ACV – Connects COMMON and V–Ω jacks to the ac voltage measuring circuits

2. **Range switch**

This is a six position rotary switch:

200 mV uA ohms – Selects the circuits required for full range measurements of 0 to ±200 mV dc, 0 to 200 mV ac, 0 to ±200 uA dc, 0 to 200 uA ac, 0 to 200 dc ohms, depending on the position of the function switch

2, 20 200, 2000 1000 VDC 600 VAC – Selects the circuits required for full range measurements of 0 to the corresponding numerical values of ac mA, ±dc mA, KΩ, ±dc V, or ac V, depending on the position of the function switch

20 megΩ – Selects the circuits required for the full range measurement of resistance from 0 to 20 MΩ when the function switch is set to the kΩ position

3. **COMMON jack**

Connects to the internal circuit ground and is insulated from the case and power line ground. **WARNING: Do not "float" this terminal more than 1000V (dc plus ac peak) above power line ground**

4. **V–Ω jack**

Connects to the voltage and resistance measuring circuits through the range and function switches

5. mA jack

Connects to the current measuring circuits through the range and function switches

6. ANALOG READOUT

This is a 0 to 200 uA dc full scale meter which indicates in analog form the negative, positive, or ac value being displayed on the digital readout. Its input is obtained from a digital to analog conversion circuit. This meter also indicates the battery condition under normal load when the BATTERY TEST switch is depressed.

7. BATTERY TEST switch

This is a push-button switch. In the depressed position, the ANALOG READOUT is disconnected from the signal measuring circuits and connected to measure and indicate the condition of the internal cells under normal load.

8. Digital display

This consists of a polarity (+, –) sign, a "1" digit, and three, seven segment type 0 to 9 digits and displays the polarity and value of the signal being measured. When an overrange condition exists the lower half of the "1" digit will extinguish and the upper half will flash intermittently.

9. ZERO adjust

This is a multi-turn trimmer potentiometer which is screwdriver adjusted to vary the dc offset voltage at the input to the integrator amplifier circuit. It is adjusted to obtain a digital indication of 000 when the input terminals are shorted together.

Figure 3–2, Rear Panel

10. GROUND jack

This is electrically connected to the case and the ac line cord ground wire. Refer to para. 4.2.8.

11. +V, –V, Ω, 20 MEGΩ

These are adjustments for calibrating the internal circuits to a voltage and resistance standard.

CAUTION

These adjustments should only be made by a qualified technician knowledgeable in the precautions, procedures and equipment required.

Figure 3-1, Front Panel

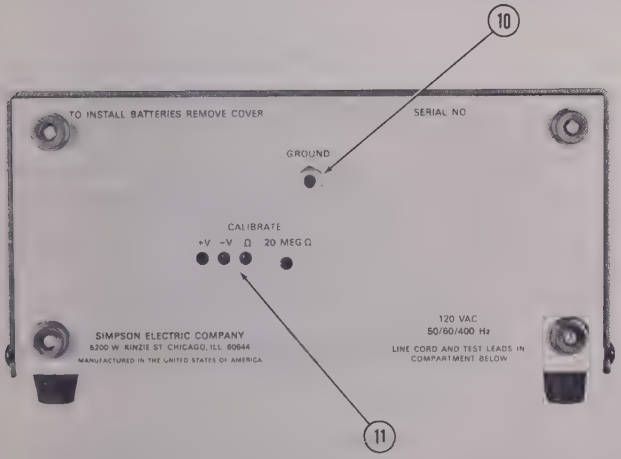


Figure 3-2, Rear Panel

SECTION IV

OPERATION

4.1 GENERAL

WARNING

The Simpson 460 is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to do so may result in a SERIOUS or FATAL accident.

This section of the manual contains all the information related to operation of the Instrument. Special notes and instructions have also been provided for added safety and convenience.

4.2 PRECAUTIONS

WARNING

Failure to heed the following safety precautions may result in a SERIOUS or FATAL accident.

4.2.1 Remember, voltages may appear unexpectedly in defective equipment. An open bleeder resistor may result in a capacitor retaining a dangerous charge. Turn off power and discharge all capacitors before connecting or disconnecting the test leads from the circuit being measured.

4.2.2 Locate all voltage sources prior to making any measurement or connections.

4.2.3 For your safety, inspect the test leads for cracks, breaks or crazes in the insulation before each use. If any defects exist, destroy and replace the test lead immediately.

4.2.4 Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color emanation from sharp metal points in the circuit, the odor of ozone and its sound.

4.2.5 Hands, shoes, floor and workbench must be dry.

4.2.6 For maximum safety, do not touch test leads or Instrument while power is applied to the circuit being measured.

4.2.7 Use extreme caution when making measurements in an rf circuit where a dangerous combination of voltages could be present such as in a modulated rf amplifier.

4.2.8 Before the unit is used, be sure that the case is grounded. For ac line operation this will be automatic if the electrical outlet has a third wire ground (latest electrical code). If it is a two wire system requiring a 3 prong to 2 prong adapter, insure that the third wire (ground) from the adapter is connected to an earth (power line) ground. NOTE: This can also be accomplished if the rear panel GROUND terminal is connected directly to earth ground.

4.2.9 Do not float the COMMON terminal more than 1000 volts (dc plus ac peak) with respect to the case and/or ground.

4.2.10 Do not operate the 460 without knobs or use knobs (or set screws) which differ from those originally supplied with the instrument. Refer to 6.11.

4.3 PRELIMINARY NOTES, CHECKS, AND ADJUSTMENTS

Prior to operation of the Instrument the following notes, checks, and adjustments should be followed or performed. These may also be used as a general functional check.

4.3.1 If the Instrument is to be ac line operated, check that the power source used matches the requirements of the unit as marked on the rear panel. Then, remove the line cord from its compartment (in the bottom of the instrument) which is accessible by sliding the compartment door forward. Insert the plug into a convenient 3 wire power outlet which conforms to the latest electrical code. Refer to para. 4.2.8.

4.3.2 If battery operation is used depress the front panel BATTERY TEST button. See 6.5 for battery installation. The ANALOG READOUT should indicate within the BATT markings on the scale. If it does not, the batteries should be recharged. Refer to para. 6.6.

4.3.3 The case should always be connected to earth ground through the GROUND terminal on the rear panel (See Figure 3-2) when battery operation is used. This protects against accidental shock from the metal case when measuring high potentials. It also shields the Instrument from interference fields in high noise areas.

4.3.4 Connect the black test lead to the COMMON jack and the red to the V–Ω jack.

4.3.5 Short the test leads together, rotate the function switch to the DCV position, and the range switch to 200

mV/uA/ohms. The digital display should be 00.0. Ideally the polarity sign will switch alternately between (–) and (+). If not, accomplish this by adjusting the trimmer potentiometer located just behind the hole marked ZERO on the front panel, using a thin bladed screwdriver. Refer to Table 3-1, item 9, and Figure 3-1.

4.3.6 The following check will indicate whether a majority of the circuits are functioning properly. It is not an absolute test on all sections of the Instrument, but it can be used as a general operational check.

a. Set the function switch and range switch at DCV and 200 mV with the COMMON and V–Ω test leads shorted together.

b. Remove the short. The digital display should count from 00.0 to –199.9.

c. When –199.9 is reached, overrange occurs, the lower half of the 1 digit will extinguish and the upper half should flash intermittently. Short the test leads together. The digital indication should return to 00.0

4.3.7 There are four calibration adjustments located behind the rear panel as shown in Figure 3.2. These do not ordinarily require adjustment,and your nearest Simpson representative should be consulted if the accuracy of the Instrument appears to differ from the specifications contained in Table 1-1.

CAUTION

Improper rotation of these controls can result in the necessity for complete recalibration according to factory procedures using appropriate precision standards.

4.4 INITIAL CONNECTIONS AND CONTROL SETTINGS

4.4.1 Accomplish the Preliminary Notes, Checks, and Adjustments, para. 4.3.1. through 4.3.4.

4.4.2 Rotate the function selector switch to the DCV position.

4.4.3 Rotate the range switch to the 2000 position.

4.5 DC VOLTAGE MEASUREMENT

WARNING

Prior to making measurements review the PRECAUTIONS (Refer to 4.2.)

4.5.1 Accomplish the initial connections and control settings, (Refer to 4.4.).

4.5.2 Rotate the range switch to the appropriate position. If the voltage being measured is unknown, rotate the switch to the 1000 VDC position. CAUTION: Do not attempt to measure voltages which may be greater than 1000 volts.

4.5.3 Remove all power from the circuit being measured and discharge all capacitors.

4.5.4 Attach the test leads to the circuit being measured. Be careful not to contact adjacent points. Apply power to the

circuit being measured. Do not touch the test leads or the Instrument.

4.5.5 The value of the voltage being measured is indicated on the digital and the analog readouts. Remove all power from the circuit being measured, discharge all capacitors, and disconnect test leads.

4.6 AC VOLTAGE MEASUREMENT

WARNING

Prior to making measurements review the PRECAUTIONS (Refer to 4.2.).

4.6.1 Accomplish the initial connections and control settings, (Refer to 4.4.).

4.6.2 Rotate the function selector switch to ACV.

4.6.3 Rotate the range switch to the appropriate position. If the voltage being measured is unknown rotate the switch to the 600 VAC position. CAUTION: Do not attempt to measure voltages which may be greater than 600 volts rms.

4.6.4 Remove all power from the circuit being measured and discharge all capacitors.

4.6.5 Attach the test leads to the circuit being measured. Be careful not to contact adjacent points. Observe proper grounding of the Simpson 460 case as specified in para. 4.2.8 and 4.3.3.

4.6.6 Apply power to the circuit being measured. Do not touch the test leads or the Instrument.

4.6.7 The value of the voltage being measured is indicated on the digital and the analog readouts.

4.6.8 Remove all power from the circuit being measured, discharge all capacitors, and disconnect test leads.

4.7 DC RESISTANCE MEASUREMENT

4.7.1 Accomplish the initial connections and control settings, (Refer to 4.4.).

4.7.2 Rotate the function selector switch to KΩ.

4.7.3 Rotate the range switch to the appropriate position.

4.7.4 If the resistance being measured is connected in a circuit, be certain that all power is removed from the circuit and all capacitors are discharged. Check for alternate resistance paths other than the resistance being measured. These paths can result in a measured value which is lower than the actual value of the resistance being measured.

4.7.5 Connect the test leads to the resistance being measured. Be careful not to contact adjacent points, even if insulated, particularly when making high resistance measurements. For example, some insulators can have relatively low insulation resistance. This can sufficiently shunt the resistance being measured to result in a measured value lower than the actual.

NOTE: If the resistance being measured is polarity or voltage sensitive (for example, semiconductors), this must be considered when making connections and selecting the resistance

range (Test current is different for each resistance range. Refer to Table 1-1, item 2). The polarity of the COMMON jack is negative with respect to the V-Ω jack.

4.7.6 The value of the resistance being measured is indicated on the digital and analog readouts.

NOTE: Allow time for the readout to stabilize. This is especially important when measuring high value resistances shunted by large value capacitances.

4.7.7 Disconnect test leads.

4.7.8 If no additional, immediate resistance measurements are required, rotate the function switch to the OFF, DCV, or ACV position. Rotate the range switch to the 2000 position. This avoids the possibility of accidentally applying voltage to the resistance circuits, and causing the internal protective fuse to open.

4.8 DC CURRENT MEASUREMENT

WARNING

Prior to making measurements review the PRECAUTIONS (Refer to 4.2.).

4.8.1 Accomplish the initial connections and control settings,(Refer to 4.4.).

4.8.2 Rotate the function selector switch to DC mA.

4.8.3 Rotate the range switch to the appropriate position. If the current being measured is unknown rotate the switch to 2000.

4.8.4 Remove all power to the circuit being measured and discharge all capacitors. Open the circuit in which the current is to be measured and connect the test leads in series. Observe the correct polarity and insure that the 460 is not connected across a voltage source which may result in a current through the Instrument in excess of the range position marking (or 2000 mA on the 2000 position). Failure to do so may cause the internal protective fuse to open.

4.8.5 Apply power to the circuit being measured. Do not touch the test leads or the instrument.

4.8.6 The value of the current being measured is indicated on the digital and analog readouts.

4.8.7 Remove all power from the circuit being measured and discharge all capacitors.

4.8.8 Disconnect the test leads and reconnect the circuit which was originally opened.

4.8.9 If no additional, immediate current measurements are required, rotate the function switch to the OFF, DCV, or ACV position. This avoids the possibility of accidentally applying voltage to the current circuits, which may cause the internal protective fuse to open.

4.9 AC CURRENT MEASUREMENT

WARNING

Prior to making measurements review the PRECAUTIONS (Refer to 4.2.).

4.9.1 Accomplish the initial connections and control settings, (Refer to 4.4.).

4.9.2 Rotate the function switch to AC mA.

4.9.3 Rotate the range switch to the appropriate current position. If the current being measured is unknown rotate the switch to 2000.

4.9.4 Remove all power from the circuit being measured and discharge all capacitors.

4.9.5 Open the circuit being measured and connect the test leads in series. Insure that the 460 is not connected across a voltage source which may result in a current through the Instrument in excess of the range position marking (or 2000 mA on the 2000 position). Failure to do so may cause the internal protective fuse to open.

4.9.6 Apply power to the circuit being measured. Do not touch the test leads or the Instrument.

4.9.7 The value of the current being measured is indicated on the digital and analog readouts.

4.9.8 Remove all power from the circuit being measured and discharge all capacitors.

4.9.9 Disconnect the test leads and reconnect the circuit which was initially opened.

4.9.10 If no additional, immediate current measurements are required, rotate the function switch to the OFF, DCV or ACV position. This avoids the possibility of accidentally applying voltage to the current circuits, which may cause the internal protective fuse to open.

SECTION V

THEORY OF OPERATION

5.1. OVERALL SYSTEM

5.1.1 The basic system diagram for the 460 is shown in Figure 5-1.

5.1.2 The parameter being measured is connected to the appropriate input terminals. The corresponding Range, Function, and Signal Conditioning Circuits convert this parameter into a proportional and numerically equal dc voltage.

5.1.3 This dc voltage is applied to a 3½ Digit, Bipolar (dual polarity) DC Digital Voltmeter circuit. The measured voltage is displayed both on a seven segment type digital readout and an Analog Meter. The indicated value is equal to the magnitude of the parameter being measured.

5.1.4 The Power Supply provides the ac and dc operating voltages required by the signal conditioning and digital voltmeter circuits, and the dc charging current for the rechargeable battery.

5.2 INPUT CIRCUITS

5.2.1 DC Voltage Measurements – The basic dc voltage measurement circuit is shown in Figure 5-2, (a).

5.2.2 The dc voltage being measured is connected to the V–Ω and COMMON inputs, attenuated according to the range selected, and measured by the digital voltmeter circuit.

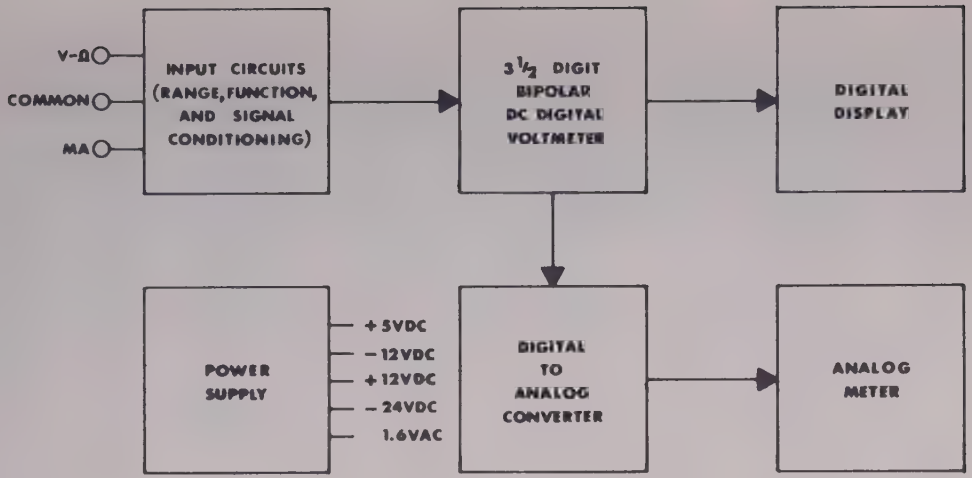


FIGURE 5-1
BASIC SYSTEM DIAGRAM

5.2.3 The digital voltmeter circuit provides a choice of two full range sensitivities: 200 mV and 2 V. This simplifies the attenuator design:

a. No attenuation is required on the 200 mV and 2V ranges. The range changing is accomplished by changing the digital voltmeter sensitivity.

b. The same attenuator is used on the 20 V and 200 V ranges (Note: A separate attenuator tap is required for the 1000 V range).

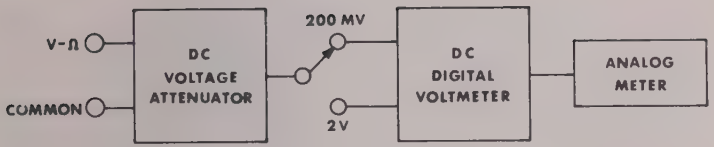
5.2.4 **AC Voltage Measurements** -- The basic ac voltage measurement circuit is shown in Figure 5-2,(b).

5.2.5 The ac voltage being measured is connected to the V–Ω and COMMON inputs, attenuated according to the range selected, and applied to an Input Amplifier. The output of the amplifier is converted into dc by an AC To DC Converter, and the resulting dc is measured by the DC Digital Voltmeter.

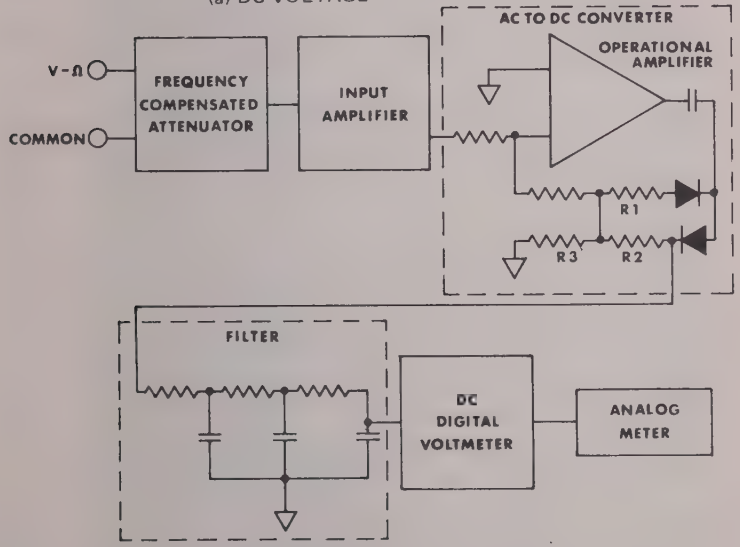
5.2.6 The attenuator is not used on the 200 mV and 2 V ranges. On the higher ranges it is frequency compensated to provide good accuracy over a wide frequency range (Refer to Table 1–1, item 3).

5.2.7 The Input Amplifier achieves a high input impedance and presents a low output impedance to the converter.

5.2.8 The AC to DC Converter uses a rectifying Operational Amplifier (inverting type) at two gain levels to provide a choice of sensitivities at its input of 200 mV or 2 V full



(a) DC VOLTAGE



(b) AC VOLTAGE

FIGURE 5-2
BASIC VOLTAGE MEASUREMENT CIRCUITS

range. It is average responding, but is calibrated (gain) based on the rms value of a sine wave.

5.2.9 The output of the Operational Amplifier has two rectifying diodes and two-feedback resistors R_1, R_2 which drive a summing resistor R_3. The junction of the summing resistor and the feedback resistors is fed back to the input to provide negative feedback. Assuming a sine wave input signal, the positive half cycles of the output waveform goes through one diode and the negative half cycles through the other. The positive half cycle is filtered by an rc network and the resulting dc is measured by the DC Digital Voltmeter circuit.

5.2.10 The indications on the digital and analog meter readouts are equal to the magnitude of the ac voltage being measured.

5.2.11 AC Current Measurements – The basic ac current measurement circuit is essentially the same as the dc current measurement circuit (refer to 5.2.12) except that the voltage developed across the internal resistance is measured by the ac voltage measurement circuit instead of the dc circuit.

5.2.12 DC Current Measurements – The basic dc current measurement circuit is shown in Figure 5-3, (a).

5.2.13 The current being measured is connected in series with the mA and COMMON inputs and an internal precision resistance. The value of the resistance depends on the current range used and is selected so that the voltage developed across it is proportional and numerically equal to the current through it. The digital voltmeter circuit measures this voltage, and the

value indicated on the digital and analog meter readouts is equal to the current being measured.

5.2.14 The full range sensitivity of the digital voltmeter circuit for current measurements is 200 mV. Therefore, the internal resistance for each current range equals 200 mV divided by the full range current. For example, if the full range current is 200 uA, then the internal resistance would be 1000 ohms.

5.2.15 **Ohms** – The basic dc ohms circuit is shown in Figure 5-3, (b).

5.2.16 The resistance being measured, R_X, is connected to the V–Ω and COMMON inputs, and a constant current is applied through it by the Instrument. The resulting voltage is proportional and numerically equal to the value of R_X. The value of the current is determined by the resistance range used.

5.2.17 The current through R_X is controlled by an Operational Amplifier whose inputs "follow" E_X and the output is always E_X + 1 volt. The 1 volt reference for the amplifier is developed by the current from a Constant Current Source through a 1 kΩ feedback resistor.

5.2.18 The E_X + 1 volt output of the amplifier maintains a constant current through R_X, regardless of the value of R_X. The magnitude of the current is determined by the resistance (precision resistors selected by the ohms range switch) in series with R_X.

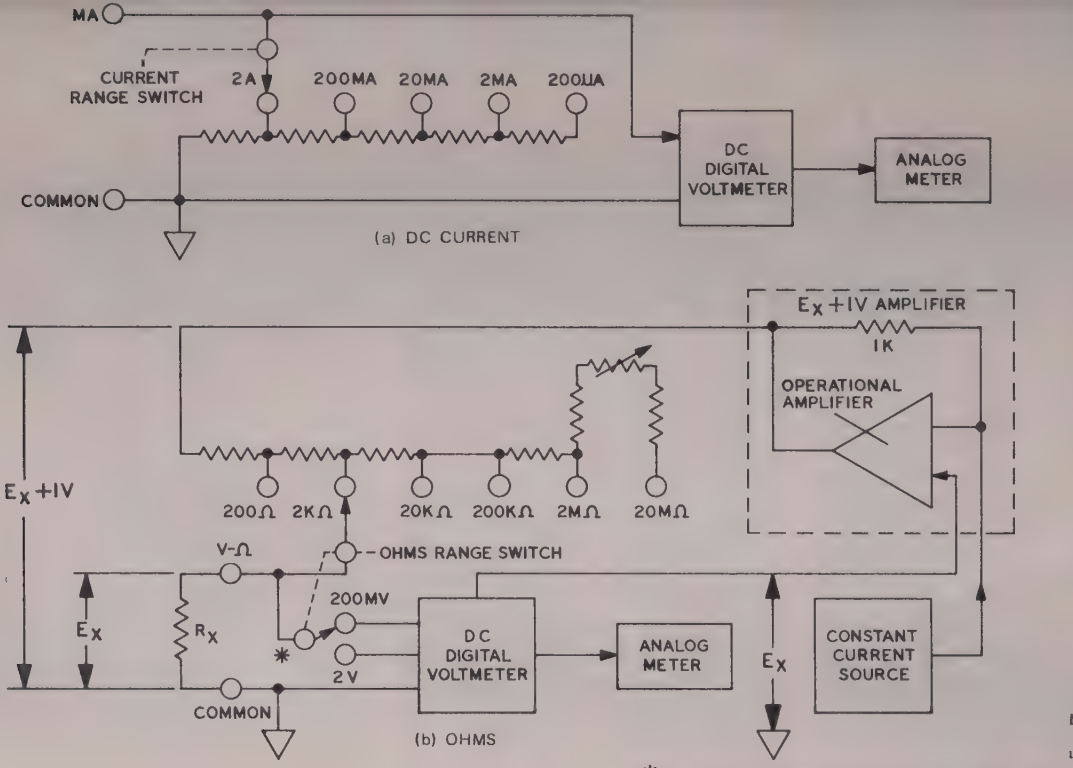


FIGURE 5–3 BASIC DC CURRENT AND RESISTANCE MEASUREMENT CIRCUITS

5.2.19 The digital voltmeter measures the voltage developed across R_X, and the value indicated on the digital and analog meter readouts is equal to the resistance of R_X.

5.3 DIGITAL VOLTMETER CIRCUIT

5.3.1 **General** - The basic block diagram of the digital voltmeter circuit is shown in Figure 5-4. It utilizes the dual slope integration technique for the analog to digital conversion. This achieves excellent accuracy, stability, and noise immunity. The term "dual slope" is derived from the two slope operation of the integrator.

5.3.2 **Operation** - The incoming dc voltage is sampled and measured at the input of the integrator 5 times per second. The sampling interval, T1, is initiated by a pulse from the Zero Detector circuit, and the measuring interval, T2, by an "overflow" pulse from the Counter Circuits. See Figure 5-5 for the basic timing diagram (shown for a positive input signal).

5.3.3 During T1, the integrating capacitor charges and the Integrator output increases in accordance with the polarity and magnitude of the input signal. At the same time the Counter Circuits are counting the pulses generated by the 40 kHz Clock Oscillator. At the count "8000" an "overflow" pulse is generated by the Counter Circuits and the counters reset to zero.

5.3.4 The "overflow" pulse actuates the Control Logic circuits which select a Precision Current Reference of proper polarity and connects it to the Integrator input. The first

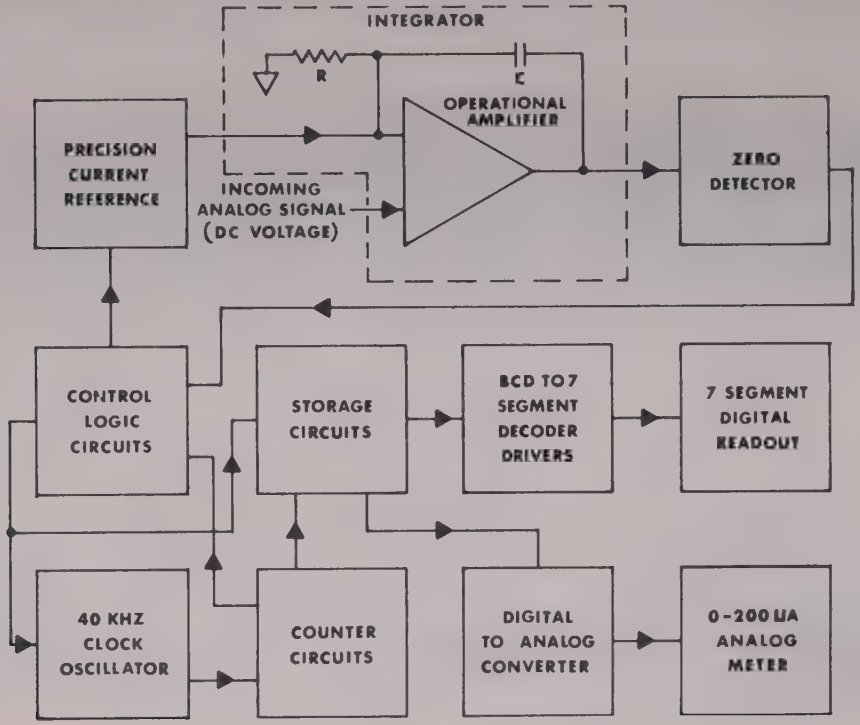


FIGURE 5-4
BLOCK DIAGRAM OF DIGITAL VOLTMETER

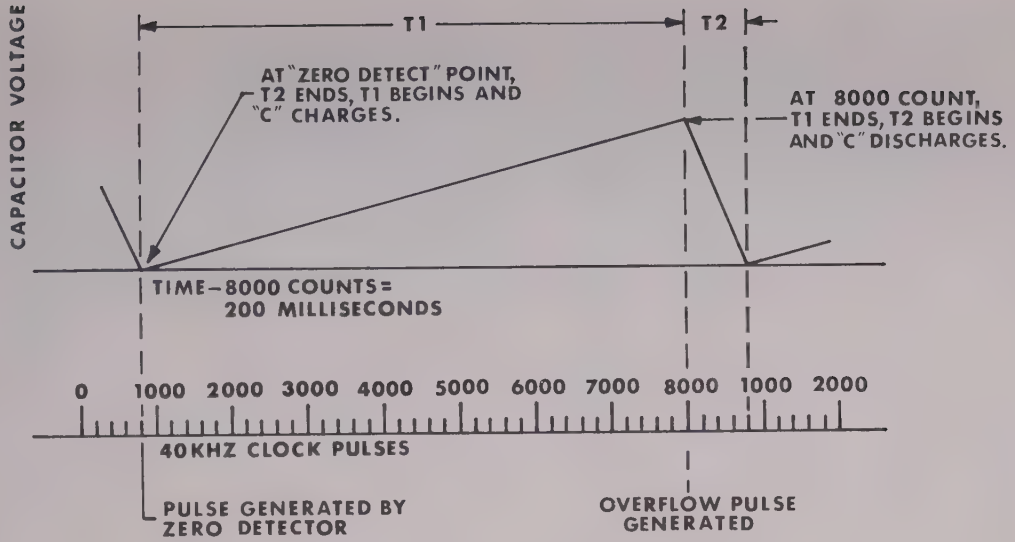

CAPACITOR VOLTAGE
T1
T2
AT "ZERO DETECT" POINT, T2 ENDS, T1 BEGINS AND "C" CHARGES.
AT 8000 COUNT, T1 ENDS, T2 BEGINS AND "C" DISCHARGES.
TIME–8000 COUNTS= 200 MILLISECONDS
0 1000 2000 3000 4000 5000 6000 7000 8000 1000 2000
40KHZ CLOCK PULSES
PULSE GENERATED BY ZERO DETECTOR
OVERFLOW PULSE GENERATED

FIGURE 5-5
BASIC TIMING DIAGRAM FOR THE 460

integrating interval, T1, is ended, and the second integrating interval, T2, starts.

5.3.5 During T2, the current reference causes C to discharge, and the voltage at the output of the Integrator to decrease towards zero. At the same time the Counter Circuits are counting the pulses generated by the 40 kHz clock. The counting continues until the Integrator output reaches zero. At zero cross-over the Zero Detector generates a pulse which, through the Control Logic Circuits, inhibits (stops) the clock for a very short time and the accumulated count is transferred to the Storage Circuits as an equivalent BCD signal. The second integrating interval, T2, is now ended, the current reference is disconnected and the cycle repeats (T1 starts).

5.3.6 The BCD to 7 Segment Decoder/Driver and the Digital to Analog circuits convert the accumulated count (BCD signal) into suitable signals for driving a 7 segment type digital readout and a 0 to 200 microampere Analog Meter. The numerical and polarity indications are equal to the value of the analog signal at the input of the Integrator.

5.3.7 The other requirements of the digital voltmeter circuit such as overrange, out of range, and polarity indications are accomplished by the Control Logic and Counter Circuits.

5.4 POWER SUPPLY CIRCUITS

5.4.1 The basic block diagram for the 460 power supply circuits is shown in Figure 5-5.

5.4.2 When the 460 is operated from an ac power line, the incoming ac power is applied to transformer T1. The two primary windings are connected in series for 234 volt and in parallel for 117 volt operation. T1 steps down the voltage as required by the Rectifier Circuit.

5.4.3 The Rectifier Circuit is a full wave, bridge type and converts the incoming ac into an unregulated dc voltage. This unregulated voltage is applied to a Series Type Regulator Circuit. The output from the regulator is 8 volts. R1 and R2 provide the proper charging current for the battery and drop the 8 volts to 5 volts as required by the dc to dc converter, and the logic/digital circuits. Note: The ac/battery switch is automatically set to the battery position when cells are installed.

5.4.4 The dc to dc converter changes the 5 volt dc input into an ac signal. This ac signal is then stepped up and rectified to provide regulated outputs of plus and minus 12 volts dc and an unregulated output of minus 24 volts dc. It is also stepped down to provide an ac output of 1.5 volts as required by the filaments of the digital display tubes.

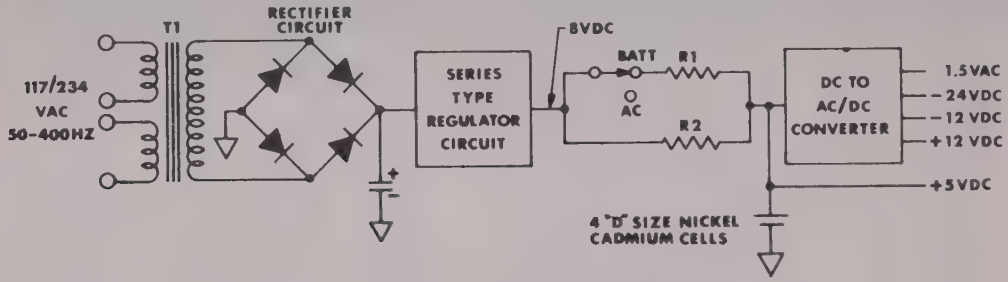


FIGURE 5-6
BLOCK DIAGRAM OF THE 460 POWER SUPPLY

SECTION VI

MAINTENANCE

6.1 GENERAL

WARNING

This Instrument contains internal voltages which constitute a SHOCK HAZARD. Only Simpson Authorized Service Centers or factory personnel should disassemble any part of the Instrument.

The Simpson 460 is carefully designed and constructed with high quality components. By providing reasonable care, and following the instructions in this manual, the user can expect a long, useful service life.

6.2 WARRANTY

The Simpson Electric Company warranty policy is printed on the inside back cover of the manual. Read carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact your nearest Authorized Service Center for instructions. These are listed on the last pages of the manual. If you wish to contact the factory directly, give full details of the difficulty and include the instrument model number, serial number and date of purchase. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of the Instrument under warranty beyond one-way transportation charges. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted.

This charge will not be exceeded without prior approval. Repair charges will be billed on the basis of cost.

6.3 SHIPPING

6.3.1 The Instrument should be packaged carefully, less batteries, and shipped prepaid to the destination indicated. Insure the instrument.

6.4 COVER REMOVAL

The top cover can be removed for maintenance purposes by the following procedure:

WARNING

Remove all power and connections to the Instrument prior to removing the case cover.

6.4.1 Rotate the function switch to the OFF position.

6.4.2 Disconnect the line cord from the power source and all connections from the Instrument.

6.4.3 Remove the two phillips head screws near the front, on each side of the cover, and loosen the two rear screws.

6.4.4 Position the handle upright (top of case). Then lift the front of the cover up, pull forward to clear rear screws and remove.

6.4.5 Reverse this procedure when replacing the cover.

6.5 BATTERY INSTALLATION

6.5.1 The cells can be installed by the following procedure. Be certain to use the type specified in Table 1-1.

CAUTION

Standard size D flashlight cells can be used in an emergency. However, the power line fuse must be removed to prevent charging these cells in the instrument. This type cell does not have provision for pressure relief and can burst when charged. Immediately remove the cells when the emergency is over or they are exhausted.

6.5.2 Remove cover (Refer to 6.4). Remove the cell retainer tubings from the battery holder. Insert two cells into each retainer. Then install the combination into the holder. CAUTION: Insure that the cells are installed according to the polarity orientation designated on the battery holder label. Failure to do so may damage the 460. NOTE: The spring loaded switch located near the center of the battery holder must be positioned to allow cell installation into that section of the holder. This switch connects the battery charging circuit when cells are installed and automatically returns to the noncharging position when cells are removed.

6.5.3 Check that the battery holder and cell contacts are clean and making good connection.

6.5.4 Depress the BATTERY TEST switch. The analog readout should indicate within the BATT markings on the meter scale. If not, check battery polarity orientation. If it is correct, recharging is required. Refer to para. 6.6.

6.5.5 Replace the cover.

6.6 BATTERY RECHARGING

The battery is being charged whenever the Instrument line cord is connected to the ac power line. NOTE: Approximately 2.5 hours charging is required for each hour of usage. Refer to Table 1-1, item 9.

6.7 BATTERY CARE

6.7.1 Avoid allowing the cells to fully discharge. Check the battery condition periodically by depressing the BATTERY TEST switch. Refer to para. 6.5.4.

6.7.2 Whenever the line cord is disconnected and the Instrument is not in use remember to rotate the function switch to the OFF position.

6.7.3 If the Instrument is to be stored or not in use for long periods of time the cells should be recharged for 16 hours prior to storage to insure a fully charged battery at the time of storage. This should be repeated each month the Instrument is not in use to maintain a full charge.

6.8 DIGITAL DISPLAY TUBES

6.8.1 With normal usage, long life can be expected from the digital display tubes. When replacement is necessary the tube required can be purchased from your nearest Simpson Authorized Service Center. There are three different type tubes used. Therefore, be careful to order the correct replacement (Refer to Figure 6-1 and Table 7-2).

6.8.2 Remove the cover as explained in 6.4.

6.8.3 The defective tube may be removed by lifting it from its socket. Be careful to not apply excessive force to the tubes, sockets, or printed circuit board.

6.8.4 The correct replacement may be identified by Figure 6-1 or by noting the number of pins and cathode structure on each tube. From left to right as viewed from the front, the first has a polarity sign (+) and a "1" digit (two segments). The first and fourth tubes have nine pins and the second and third have ten pins.

6.8.5 After the tubes and corresponding sockets have been identified, each replacement tube can be installed. CAUTION: Be careful to align the tube pins with the corresponding socket jacks prior to insertion and do not apply undue force. The open space between pin number one and nine pin tubes should face toward the rear of the Instrument. The offset tenth pin on the ten pin tubes should face the rear. It is also helpful to observe the cathodes through the filter window making certain they are parallel to the window.

6.9 LINE FUSE REPLACEMENT

6.9.1 The line fuse (F3) is located adjacent to the power transformer as shown in Figure 6-1.

WARNING

Remember to remove all power and connections from the Instrument.

6.9.2 Remove the cover as described in 6.4.

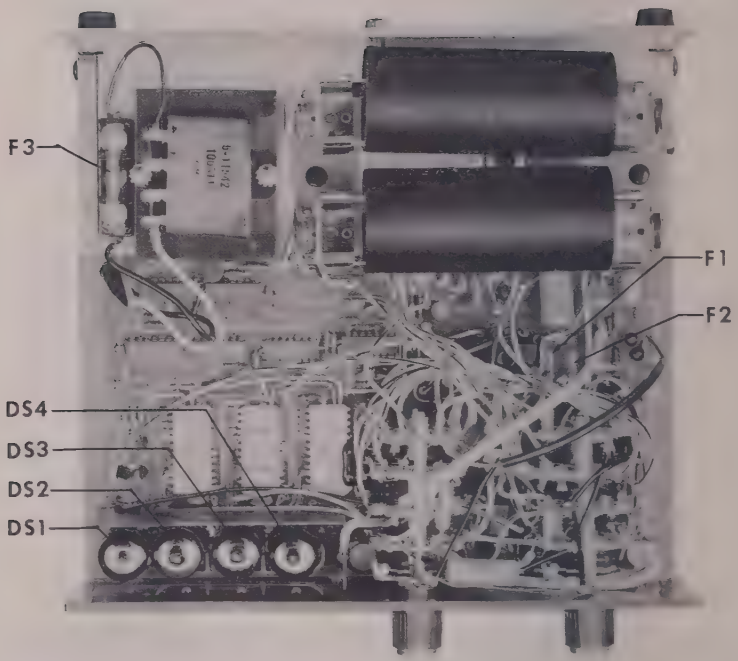


FIGURE 6-1
COVER REMOVED

6.9.3 Carefully lift the defective fuse from the holder and replace with a type 3AG equivalent (Refer to parts list for ratings).

6.9.4 Replace the cover.

6.10 CURRENT AND RESISTANCE FUSE REPLACEMENT

6.10.1 These fuses are soldered to standoff terminals located on the printed circuit board approximately 3/4 inch to the rear of the function switch (Refer to Figure 6–1). They can be purchased from your nearest Simpson Authorized Service Center. CAUTION: Insure that the replacement fuse is an exact equivalent. Refer to Table 7.2.

6.10.2 Remove the cover as described in 6.4.

6.10.3 Cut the leads of the defective fuse to remove it. Wrap the leads of the new fuse around the standoff terminals. Carefully solder the connections using electronic grade rosin flux solder. CAUTION: Avoid excessive heating of the fuse, printed circuit board, and surrounding components. Use of a 40 watt soldering iron is recommended.

6.10.4 Replace the cover.

6.11 KNOB REMOVAL

WARNING

Do not operate the Simpson 460 without knobs or use knobs (or set screws) which differ from those originally supplied with the Instrument.

6.11.1 For optimized performance, the shafts of the function and range switches are connected to the COMMON input terminal. Therefore, if the common terminal is floated (above power line ground) a shock hazard can exist between the shafts and power line ground. The shafts are insulated from the user by the knob design and having the fastening set screws below the knob surface.

6.11.2 As an added precaution the fastening set screw (metal) is covered with a nylon set screw.

6.11.3 To remove or replace the knobs:

a. Remove the nylon set screw to provide access to the fastening set screws.

b. Loosen fastening set screws (requires 1/16" hex key wrench) and remove knob.

c. To reinstall the original knobs or install replacement knobs, reverse the above procedure. Do not forget to install the nylon set screw.

6.12 PREVENTIVE MAINTENANCE

6.12.1 Daily care:

a. Immediately clean all spilled materials from the Instrument and wipe dry. If the spillage is corrosive, use a suitable cleaner to remove it and neutralize the corrosive action.

b. Whenever the Instrument is not in use rotate function switch to the OFF position. If the Instrument

has been battery operated, connect the line cord to the power line for 16 hours to insure a fully charged battery.

c. Whenever possible, avoid prolonged exposure or usage in areas which are subject to: temperature and humidity extremes; vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interferences.

d. Repair scratches or abrasions as soon as possible to maintain a corrosion free finish.

6.12.2 Monthly Care:

a Verify Instrument precision by performing operational checks using known value sources. If the need for calibration is indicated, contact your nearest Authorized Simpson Service Center.

b. If the battery is installed and has not been used for 30 days, connect the line cord to an ac power source for 16 hours. This will insure a fully charged battery condition.

6.12.3 Annual Care:

It is recommended that the Instrument be returned annually to a Simpson Authorized Service Center or the factory for a complete overall check, adjustment, and calibration.

6.12.4 Storage:

When the Instrument is not in use it should be stored in a room free from temperature extremes, dust and corrosive fumes, and mechanical vibration or shock. The cells should be removed.

6.13 TROUBLE SHOOTING

6.13.1 If the Instrument does not yield satisfactory results, accomplish the following prior to attempting maintenance on the Instrument.

a. Perform Preliminary Notes, Checks, and Adjustments, para. 4.3.1 through 4.3.4.

b. Check that all controls are positioned correctly for the parameter and range of value being measured and that the measurement is within the rating of the Instrument.

c. If Instrument is ac line operated, insure that power source is within the Instrument specifications, and free from excessive fluctuations and transients. This can be checked by comparing performance with battery operation.

d. Insure that the environment in which the Instrument is being used is within the instrument specifications.

e. Inspect the device being measured and the measurement test set-up to insure that proper shielding and grounding techniques have been used. If power line effects are suspect, operate Instrument on battery. Also check that the Instrument is not significantly affecting the circuit being measured and that the measurement is valid. For example, ac accuracy can be affected by waveform distortion.

6.13.2 If the steps taken in para. 6.13.1 do not yield satisfactory results, refer to the trouble shooting chart (Table 6-1). This chart contains instructions which can be performed by a qualified technician but do not require specialized knowledge or facilities. All other repairs and adjustments should be directed to a Simpson Authorized Service Center.

TABLE 6–1, TROUBLE SHOOTING CHART

Symptom	Probable Causes	Cure
1. No indication on the digital readout or analog meter when Instrument is battery operated. AC operation is OK.	Cells discharged, defective, not installed properly, making poor contact, or missing	Check battery condition. Refer to para. 6.5.4. If OK contact nearest Simpson Authorized Service Center. If battery checks low, remove cover and check that the cells are installed correctly and making good contact. Refer to 6.5. If they are, replace cover and charge battery overnight. Refer to para. 6.6.
2. No indication on the digital readout or analog meter when Instrument is ac line operated. (no cells installed)	a. Low or no voltage at power source receptacle b. Line cord disconnected c. Defective line cord d. Line fuse open	a. Restore correct voltage at power receptacle. b. Connect line cord. c. Repair or replace line cord. d. Replace fuse F3. Refer to 6.9.
3. Batteries do not respond to charge. Instrument operation OK when connected to ac power.	Cells defective, not installed properly, making poor contact, or missing	Remove cover and check that cells are installed correctly and making good contact. Refer to 6.5. If they are, check the voltages of the individual cells. Replace those which check significantly lower than nominal (1.25 volts).

TABLE 6–1, TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Causes	Cure
4. Operation normal on all functions and ranges except resistance.	Resistance fuse F1 open	Replace fuse F1. Refer to 6.10.
5. Operation normal on all functions and ranges except ac and dc current.	Current fuse F2 open.	Replace fuse F2. Refer to 6.10.
6. Low or no intensity on one or more of the digital display tubes.	Display tube near end of life or filament is open.	Replace display tube. Refer to 6.8.
7. Indications fluctuate and/or drift.		
a. Indication OK at 000 with the input terminals shorted and at 1000 using a stable and low impedance input.	a. Fluctuations and/or drift are being generated by the device being measured or the measurement test set up.	a. Use proper shielding, grounding techniques, and connections to minimize "pick-up" of unwanted signals due to ground loops, poor connections, and capactive and/or inductive coupling. Operate Instrument on batteries for complete isolation from the power line. NOTE: If the drift and/or fluctuation is coming from the device being measured no cure is required and the measurement is valid. Device must be corrected.

TABLE 6–1, TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Causes	Cure
b. Indications OK on battery but on ac operation fluctuate and/or drift at 000 with the input shorted and /or at 1000 using a stable and low impedance input.	b. AC power source is low or fluctuating (including transients)	b. Correct the power source or use Instrument on battery.
c. Same as 7,b except indication OK on ac but not on battery operation.	(1) Battery voltage low	(1) Check battery condition. Refer to para. 6.5.4. If not OK charge battery. Refer to para. 6.6.
	(2) One or more cells defective, not installed correctly or making poor contact.	(2) Remove cover and check that cells are installed correctly and making good contact. Refer to para. 6.5. If OK, replace all cells temporarily with conventional "D" size cells for checking purposes only. If problem still exists, contact your nearest Simpson Authorized Service Center.

TABLE 6–1, TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Causes	Cure
8. Slow response. Operation OK when using a low impedance input.	Parameter being measured has a high source impedance. For example, the full range step response on the ohms function is approximately 10 seconds when measuring 20 megohms.	None required.
9. Accuracy not within specifications when checked with a stable, higher accuracy (at least 5 times better) low impedance (voltage measurements) source.	a. Instrument is out of calibration. b. Instrument not zeroed properly.	a. Contact nearest Simpson Authorized Service Center. b. Perform ZERO adjustment. Refer to para. 4.3.5.
10. Accuracy of Instrument is within specifications but measurements appear in error.	a. Instrument affects circuit being measured. b. Common and/or normal mode specification is being exceeded	a. Study circuit being measured and Instrument specifications accordingly. b. Refer to item 7, Cure.

SECTION VII

REPLACEMENT PARTS AND SCHEMATIC DIAGRAM

Table 7-1. Operating Accessories and Supplies

Quantity	Description	Part Number
1	Test Lead Set: One black and one Red insulated lead having probe tips with provision for screw-on alligator clips (one red and one black supplied).	00115
1	Operator's Manual	5–115570

Table 7-2, Parts List

Symbol	Description	Part Number
DS1	Tube, Display, (–), (+), (1) with decimal point	5–115413
DS2, 3	Tube, Display, 0–9 with decimal point	5–115415
DS4	Tube, Display, 0–9 without decimal point	5–115414
F1	Fuse, Pico, 1/8 A, 125 V	5–115485
F2	Fuse, Pico, 3A, 125 V	5–115486
F3	Fuse, 1/2 A, 3AG	1–113233

NOTE: If the Instrument is wired for 234 Vac power source, F3 is ¼A, Type 3AG, Simpson part number 1–113835.

Test lead, Red	86–922480
Test lead, Black	86–922480
Alligator clip (without insulator)	1–115963
Insulator, Alligator clip, Red	5–112479
Insulator, Alligator clip, Black	5–111169
Knob, Range and function switch	5–115583
Knob (knurled thumb screw), Handle locking	5–115549
Feet, Rubber Bottom	5–113480
Feet, Rubber, Rear	1–117829
Screws, Cover holding	5–115424

FIGURE 7-1
POWER SUPPLY AND D/A CONVERTER

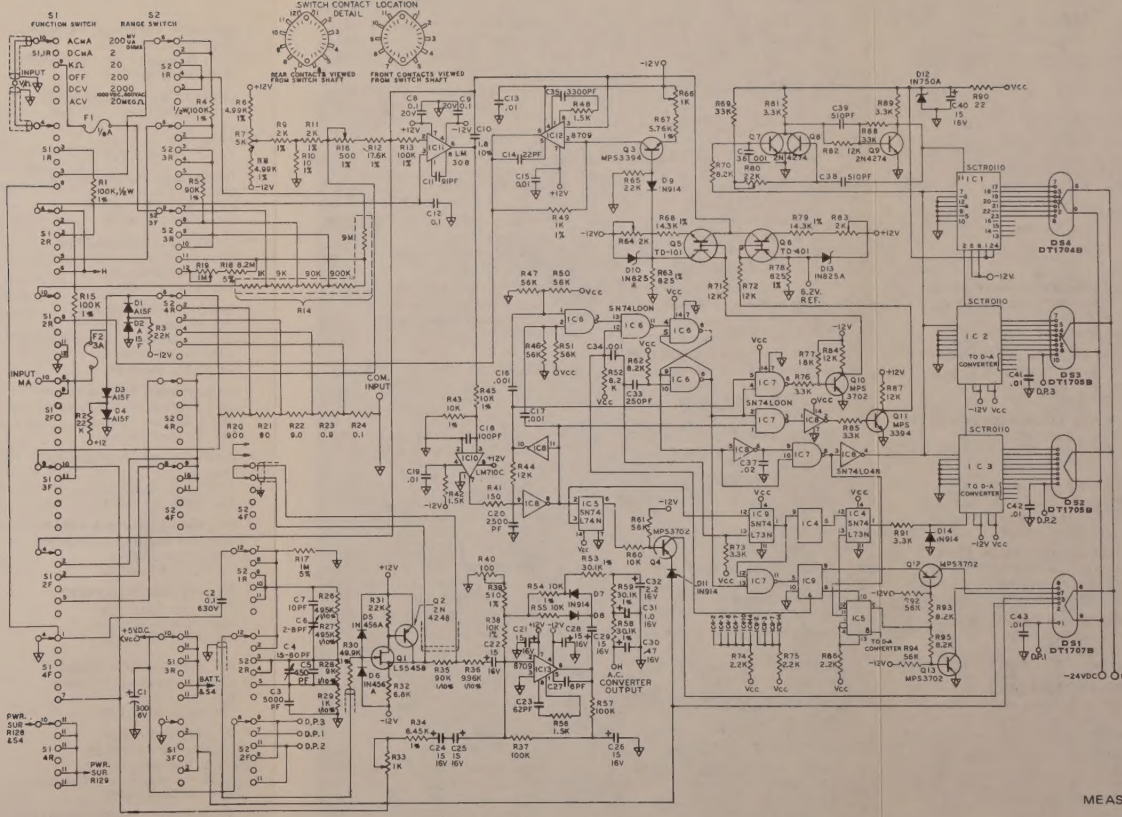


FIGURE 7-2
MEASUREMENT CIRCUITS

SIMPSON ELECTRIC COMPANY

AUTHORIZED SALES SERVICE CENTERS

*AUTHORIZED PARTS SALES & REPAIR SERVICE ONLY

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Warranty

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